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ORIGINAL ARTICLE

The interaction between universal service costing and financing in the postal sector: a calibrated approach

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Abstract The financing of universal service has traditionally relied on granting the universal service provider a reserved area. Together with growing electronic substitution, current liberalization policies promoting competitive entry may put the traditional universal service at risk. Hence, there is an increased interest in estimating the cost of universal service provision. The 3rd EC Postal Directive proposes a calculation approach to separately determine the net cost of a universal service obligation and to compensate the universal service provider (USP). This paper discusses the interaction between universal service costing and financing and shows that the EC approach may result in distorted results. It also quantifies the effects based on a model calibration with Swiss data. The results show that separate costing and financing leads to a considerable under-compensation of the USP if there is a compensation fund to which every operator contributes. The USP is over-compensated if it is exempt from contributing to the fund (pay or play mechanism). The problem of under- or overcompensation can be resolved by an integrated computation of the net cost that includes the competitive effects of the financing mechanism. Such an integrated approach results in a fair compensation of the USP.

Keywords Universal service obligation · Sharing mechanism · Compensation · Postal sector

JEL Classification L51 · L87

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1 Introduction

The financing of universal service provision in the postal sector has traditionally relied on granting the provider a reserved area. Together with increased electronic substitution, current liberalization policies promoting competitive entry may put the traditional universal service at risk; see Dietl et al. (2005) or Jaag (2007) for the Swiss case. The need for alternative funding sources has increased the interest of regulators and the public in the cost of providing universal service. Furthermore, the universal service provider (USP) may require to be compensated for its burden. This implies knowing its private cost, as measured by the profitability cost approach pioneered by Panzar (2000) and Cremer et al. (2000). It defines the net cost of universal service obligations (USO) as the difference in the USP's profit with and without the obligation.

A number of contributions have already discussed various ways to implement the profitability cost approach, see e.g. Copenhagen Economics (2008), Bergum (2009), Frontier Economics (2008), and Cohen et al. (2010). They all have treated universal service costing and financing separately (or have focused on the costing side). Only recently it has been argued that the market structure and the actual cost/burden of USO are directly related to regulation and the funding mechanism in place. Boldron et al. (2009) argue that the challenge of establishing a funding mechanism is that the market structure and the effective cost/burden of USO are endogenous to regulation and funding mechanisms.

We start from the profitability cost approach. The approach has basically been adopted by the 3rd Postal Directive 2008/6/EC (see Jaag et al. 2009). Appendix provides guidance on how to calculate the net cost of USO. Article 7 of the same directive determines the possible financing mechanisms to cover these net costs:

> Where a Member State determines that the universal service obligations […] entail a net cost […] it may introduce:
> (a) a mechanism to compensate the undertaking(s) concerned from public funds; or
> (b) a mechanism for the sharing of the net cost of the universal service obligations between providers of services and/or users.

Hence, the EU proposes a two-step approach:

1. Calculate net cost according to certain principles;
2. Compensate the USP by use of public funds or a sharing mechanism.

Thereby, various sharing mechanisms are possible. Oxera (2007) provides an overview of financing instruments. Article 7 and 9 of the 3rd Postal Directive limit the member states when implementing mechanisms to share the net costs of USO. Especially, the provisions aim at preventing member states from raising new barriers to entry. The main sharing mechanisms compliant with the 3rd Postal Directive are compensation funds to which postal operators are obliged to contribute based on their turn-over or on a per-item basis. These contributions might be waived if an operator provides universal services ("pay or play").

In our paper, we first illustrate how such compensation mechanisms affect the market equilibrium. We show that the choice of the compensation mechanism has an impact on the magnitude of the net costs, employing a model of a competitive postal sector with a stylized USO. In the model, the net cost of this obligation can be financed by the following three main compensation means compliant with the EC Directive[1]:

(1) External Funds: The USP's net costs of providing universal services are reimbursed with funds provided by the general government budget. In this scheme, no operator in the postal market contributes specifically to the USO funding.
(2) Everyone Pays: All operators contribute into a compensation fund with a uniform output tax. The USP's net costs are reimbursed by the collected funds. In such a system, the USP has to partly compensate his net costs himself.
(3) "Pay or Play": Operators that provide universal services ("play") are exempt from contributing to the compensation fund ("pay").

In the two latter cases, in which the net costs are financed by a fund, the operators' contributions are based on their revenue (ad valorem tax) or a per-unit tax. Both mechanisms are compliant with the 3rd European Postal Directive.[2] As demonstrated by Borsenberger et al. (2010), under uniform taxation schemes, the two taxation bases are not equivalent (this is confirmed by our analysis) and a per-unit tax could lead to higher welfare.

Secondly, we show that the two-step approach as foreseen by the 3rd Postal Directive results in over- or under-compensation of the USP when applied with sharing mechanisms that affect the equilibrium market outcome. We hence propose an "integrated procedure" to calculate the net costs. This allows for a fair USP compensation. Such an integrated calculation is based on the profitability cost approach and includes the compensation schedule in the model to calculate the net costs. Doing so, the compensation raised from the market players exactly leaves the USP indifferent whether to provide its public mission or not.[3]

The 3rd Directive also mentions an "unfair burden" as a prerequisite for the compensation of net costs. It has been suggested by De Donder et al. (2010) that this is linked to the USP making a loss. Boldron et al. (2009) rely on the concept of equity. They argue: "The burden is unfair if the USP's market power is not sufficient to counterbalance the weight of the USO to maintain a reasonable profit" (p. 68). Hence, according to their view, a negative profit does not necessarily imply an unfair burden. There are other interpretations of how the unfairness of a burden could be interpreted, see Jaag (2010b). We simplify our argument by assuming that net costs constitute an

[1] For an analysis of financing mechanisms compliant with Directive 2008/6/EC, see Trinkner (2009).

[2] The 3rd European Postal Directive does not impose a specific tax base for the compensation fund. An ad valorem tax or per-unit-taxes are only two possibilities. The tax could also be based on profit or other variables (see e.g. Gautier and Paolini 2010).

[3] Jaag et al. (2009) make a similar point arguing that all the net cost of individual dimensions of the USO should not be computed separately. The inherent problem with such a disaggregated approach would be the presence of interdependencies between the individual USO elements.

unfair burden. Consequently, there is compensation even if the USP makes a profit when a USO is imposed.

In the following, we show that the difference of profits between the situation without USO and a situation with USO taking into account the funding mechanism implemented is the cost of the USO that should be compensated. In this regard, we deviate from and extend the analysis by Panzar (2000) and Cremer et al. (2000) which do not include the impact of the financing instrument itself in their analysis.

Our paper is not about a welfare analysis. Hence, the "best" financing mechanism is not necessarily the one that minimizes the net cost. Similarly, it may not be optimal in any sense to impose USO in the first place. We simply argue that whenever there is a USO in place and its burden should be compensated, the level of compensation depends on the financing mechanism itself.

The rest of the paper is organized as follows. Section 2 briefly discusses the model and its calibration. Section 3 discusses the results. Section 4 concludes.

2 The model

Based on the modeling approach by Valletti et al. (2002), we analyze the interaction of universal service costing and financing after full market opening, i.e. after the abandonment of a reserved area in the market for mail. In the following, we summarize the salient features of our underlying model.[4] To isolate the effects we use a stylized model where we keep things as simple and illustrative as possible. In particular, we do not model all dimensions of the USO.

We model the postal market with one aggregate mail category for addressed mail, unaddressed mail and newspapers. Two postal operators are active in the market: A USP ("incumbent") and a competitor ("entrant"). There are no pricing restrictions and the two operators can decide on their regional coverage in the absence of USO, i.e. the regions they cover with their own delivery organization. There is no downstream access.

To analyze our research question we first define the USO. To avoid an unnecessary complex model we focus on mail delivery and assume that the USO consists of a daily and nationwide mail delivery only; there is no uniform pricing constraint. Hence, the USO operator is assumed to be able to differentiate its prices across regions.[5] We also assume that there are no obligations on the number of post offices. Related to our model, this is not a critical assumption as the process of collecting mail in post offices is independent of delivery, which is the focus of our model.

This USO constraint is binding for the operator being obliged to provide it, as long as the profit with a limited coverage is higher than with nationwide coverage. In such

[4] Details of the model are available in the Appendix.

[5] According to the 3rd Postal Directive, EU Member States are required to impose uniform pricing constraints on single piece mail only. Therefore, there are no uniform pricing constraints for the largest part of the market (the business customer segments). The Swiss postal law explicitly allows Swiss Post to negotiate with business customers over individual prices which are geared to cost.

a case, the need for a financing means arises.[6] As outlined above, we include three such financing options in our model: (1) External funds and compensation funds (2) with and (3) without contributions from USP.

There is a continuum of delivery markets, all sharing the same operator-specific demand and marginal cost characteristics, but differing in fixed costs. First, a profit-maximizing incumbent sets the proportion of markets covered, second, a profit-maximizing entrant decides on its market coverage. Third, the two operators compete in prices over differentiated mail products. From the perspective of operators, regions are ranked by increasing order of cost (or decreasing order of demographic density). Without USO, operators begin to cover the most densely populated areas and continue to cover less densely areas as long as it is profitable. In these decisions, operators take into account the anticipated incremental producer's surplus (the difference between revenue and variable cost in the incremental market) resulting from price competition in additionally covered markets. The sequence of decisions results in the incumbent always serving at equilibrium a larger proportion of the total market. This sequence in the model reflects that incumbent operators in real postal markets have traditionally been serving all markets due to the (traditional) USO. Hence, also in reality, they have a first-mover advantage. Quality other than coverage is treated as exogenous. A time-consistent solution of the model can be found by backward induction. It allows for a discussion of the competitive effects of various funding mechanisms.

In the absence of a universal service obligation, the specific cost structure together with the market penetration decisions result in a natural segmentation of the entire market into three market segments (see Fig. 1)[7]: (1) In cities and dense regions, it is feasible for two (or potentially more) companies to operate in parallel ("competitive market segment", $r < \tilde{r}$). (2) In semi-rural areas, only one operator can make a profit in the long-run. Hence, there will be a monopolistic operator in equilibrium ("monopolistic market segment", $\tilde{r} < r < \overline{r}$). (3) In rural areas, incremental coverage costs—i.e. the additional costs incurred by increasing the area covered—are higher than the producers' surplus, such that no operator serves this region voluntarily ("unserved market segment", $r > \overline{r}$).[8] We then have three kinds of markets: low-fixed cost (with a duopoly), medium fixed cost (with USP monopoly) and high fixed costs (not served unless the USP is required to). Figure 1 depicts these three markets. Because all markets share the same demand characteristics and variable costs, the equilibrium price in each market depends only upon the number of competitors. The range of duopoly markets is obtained by comparing incremental producer's surplus of the entrant—i.e. the surplus obtained by increasing the area covered—with incremental coverage cost.

[6] For simplicity, we assume that the USO net cost represents an unfair burden and compensation is necessary as soon as the net cost is positive. For an in-depth analysis of what an unfair burden may be, see Jaag (2010b).

[7] There is no obligation to set uniform prices in our model. Note, however, that within the monopoly or competitive segments, there is no reason for price differentiation, as marginal costs are constant and the relevant price elasticities of demand differ only between these two segments, but not within. Therefore marginal surplus is constant within each segment.

[8] See Jaag (2010a) for an in-depth discussion of such market segmentation.

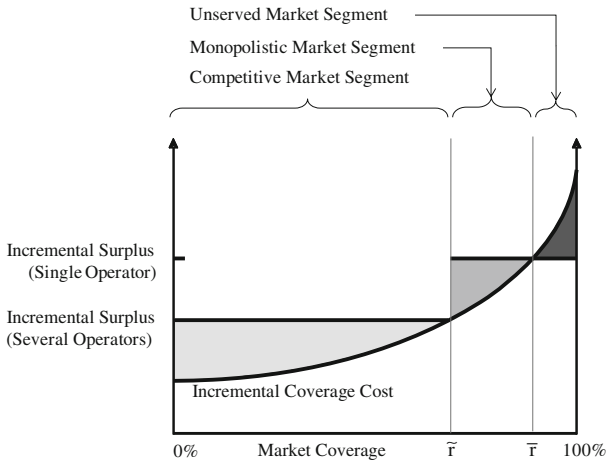

Fig. 1 The postal market without USO

The introduction of a USO forces the USP to serve areas $r > \bar{r}$ in which the incremental cost exceeds the incremental producer's surplus from extending market coverage. The regulatory authority anticipates the resulting market equilibrium and introduces a compensation mechanism before the operators decide on their market coverage and pricing. Hence, from the operators' perspective, the tax rates are predetermined. Also the USP's compensation is determined *ex ante* and not dependent *ex post* on the funds actually collected.[9] Note that the incremental producer's surplus in the monopolistic and duopolistic region is different. This is due to mutual business stealing (quantity effect) and competitive pressure on prices in the duopoly case (price effect) in the duopolistic regions.

We consider three potential funding mechanisms to compensate the USP.

(1) External financing: With external financing, there is a direct subsidy from government funds. In this mechanism, there is no (or zero) tax in the industry and the net costs are reimbursed by the government directly.
(2) Everyone pays: In this case, there is no distinction between the USP and the entrant who both pay output tax on a per-item or revenue basis.
(3) Pay or play: In this case, only the entrant (non-USP) contributes to the fund on a per-item or revenue basis. The USP is waived from the tax. Note that this is a pay or play mechanism in the sense that the incumbent provides universal services (and does not contribute to the fund) and the entrant contributes to the fund (but does not provide universal services). In our model specification and calibration it is actually optimal for the entrant not to offer universal services himself but rather to contribute to the fund.[10]

[9] Since the model is deterministic and there are no information asymmetries, the contributions to the fund just match the predetermined compensation.

[10] In practice, the difficulty with a "pay or play" system is to define the balance between the provision of universal services and the reduction of the contribution to the fund. Here, we simplify by not differentiating

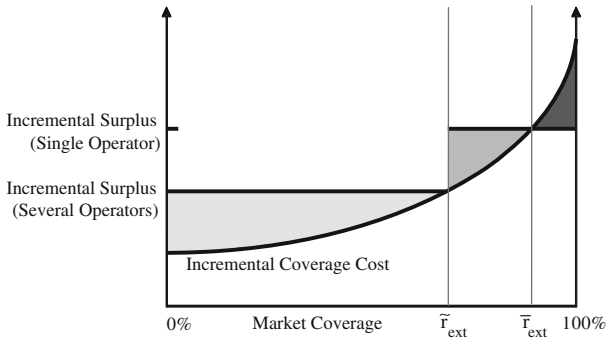

Fig. 2 The postal market with external funds

3 Qualitative results on USO costing and the effect of its financing

In this section we present qualitative results based on our formal analysis. The results from our formal analysis of the equilibrium properties can best be shown graphically. They do not depend on the chosen calibration.

External funds: Starting from an equilibrium as shown in Fig. 2, operator i (the incumbent) has the lowest incremental cost for reaching full market coverage $r = 1$. Hence it makes sense to designate (or force) operator i to provide universal delivery services. To ensure that this operator is not worse off due to this obligation, the correct compensation equals exactly its incremental costs minus the incremental revenue (the dark shaded area in Fig. 2). A compensation mechanism based on external funds has no effects on the market equilibrium.[11] Hence, the USP is neither under- nor overcompensated. In Fig. 2 this is illustrated by the two light and medium shaded areas (producer's surpluses of the operators in the competitive and monopolistic segments, respectively) which remain unchanged by the USO designation and compensation. Note that the figure is simplified for illustration purposes and assumes cost and demand functions which are symmetric for both operators.[12]

Everyone pays: With a financing of the USO by means of fund to which every operator contributes to, the incumbent's and the entrant's incremental surplus is reduced in all served market segments. This is a result of the tax which shifts the incremental producer's surplus curves downward (see Fig. 3). The intersection of the incremental surplus and the incremental cost curves shift to the left which results in reduced optimum area coverage. Due to taxation, formerly profitable regions turn unprofitable.

With respect to the real net cost of the USO, the effects in all the three regions have to be considered: The USP's total surplus in the duopolistic region is reduced due to a lower incremental surplus and the smaller size of that region. The effect on

Footnote 12 continued
between various degrees of universal service provision. Given the choice between providing full USO (together with the incumbent) and none, it is optimal for the entrant to "pay" and not to "play" in all scenarios discussed below.

11 Recall that the specification exhibits no cross-side effects between regions on the demand or cost side.

12 In the calibrated model we will assume an asymmetry in demand and incremental coverage costs.

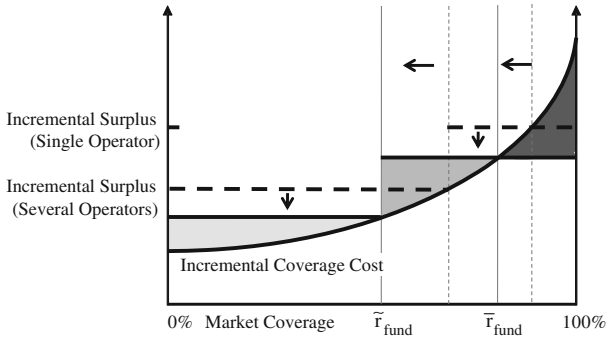

Fig. 3 The postal market with a mechanism to which everyone contributes (schematic)

the USP's total surplus in the monopolistic region is ambiguous: The total surplus is reduced due to the decrease in the incremental surplus; it is increased or decreased due to the expansion/reduction of the area. The direction of this latter effect depends on the relative reaction of $\tilde{r}$ and $\bar{r}$. Third, the total net loss in the "unserved region" increases due to its expansion and the lower incremental surplus.

The real net cost of the USO is the difference in the profit level of the USP with the USO (including its contribution to a compensation fund) and the profit level without the USO. Intuitively, the compensation has a direct and an indirect effect on the USP's profit and hence on the net cost: The direct impact is that the USP contributes itself, such that the net compensation it receives is reduced which pushes the result toward underfinancing of the USO. This effect is the stronger the more the USP's surplus in monopolistically served regions ($r > \tilde{r}_{\text{fund}}$) is reduced by the tax. The indirect effect is that the competitor reduces its market coverage, which increases the USP's profit because his monopolistic market segment is augmented. This effect pushes the result toward overfinancing of the USO because the USP effectively profits from the USO and its financing which results in the entrant partially exiting the market. This effect is the stronger the more the competitor's surplus in the duopolistically served region ($r < \tilde{r}_{\text{fund}}$) is degraded by the tax (downward shift of the incremental surplus curve) and the smaller the slope of its incremental coverage cost function, which results in a more pronounced leftward shift of the intersection of the entrant's incremental surplus and incremental coverage cost curves. The incremental coverage cost curve's slope is the smaller the less heterogeneous delivery routes. Hence, overcompensation of the USP is the more likely, the more homogeneous delivery routes are.

Hence, depending on the size of these effects, the net cost is higher or lower with an internal funding mechanism than with external financing.

Pay or play: With a financing mechanism in which the incumbent's revenue is exempt from the output tax, again the entrant serves a smaller region up to $\tilde{r}$ because the output tax it faces and its reduced incremental surplus (leftward shift of the curves indicating optimum coverage in Fig. 4). Due to the asymmetric taxation in the competitive region, the USP's incremental surplus increases in this region. Because the USP is exempt from the output tax, all revenues in the markets $r > \tilde{r}_{\text{pop}}$ are unaffected by the output tax. Hence, in contrast to the all pay mechanism, the producer's surplus in

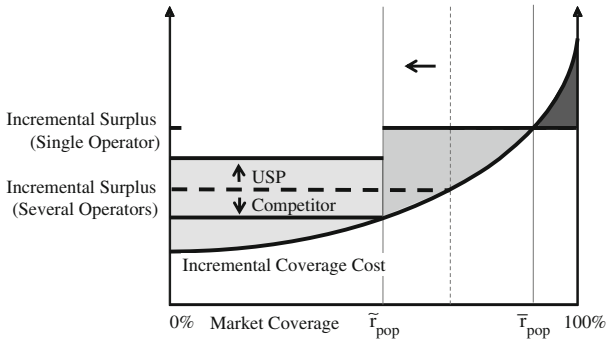

Fig. 4 The postal market with a pay or play mechanism (schematic)

these regions does not change (no output tax levied on incumbent). In all regions r where $\tilde{r}_{pop} < r < \tilde{r}_{ext}$, the USP is also exempt from the tax. In these regions, a second effect is to be considered; compared to the external funding scenario, the USP is now the sole operator and earns a higher surplus in that market.

This results in an unambiguous effect; the real net cost is smaller compared to a situation with external financing as there are strictly positive marginal effects on profits in the monopolistic segment of the market. Hence, if the USP receives an amount equal to the dark shaded area in Fig. 4, it is clearly over-compensated.

4 Quantitative results

With the above qualitative results in mind, a quantitative calculation helps to resolve the indeterminacy in the qualitative analysis and gives orders of magnitudes to the under- or over-funding of the incumbent in the Swiss case. Based on the model calibration sketched above, we provide results for the two-step approach as well as for the integrated approach in which the necessary compensation is computed in market equilibrium, hence eliminating any over- or under-compensation in all scenarios. We also differentiate between the cases in which the contribution to the compensation fund is based on revenue (Tables 1, 3) or based on a per-unit tax (Tables 2, 4).

4.1 Two-step approach (sequential calculation)

In the two-step approach, the net cost of the USO is in a first step determined by the difference in USP profits serving with optimal coverage $\bar{r}$ compared to USO coverage $r = 1$ without taking into account the effect of the sharing mechanism (first row in Tables 1 and 2).

In a second step, the output tax to be collected from the operators is determined by the competent authority. In case of external funds (first column), the output tax is 0 and net costs are reimbursed to the USP from general government funds. In this case, 63.7% of the total market is served by the entrant. In the two sharing mechanisms (second and third column), the contribution rates are computed such that the contributions

Table 1 Model results with sequential simulation and a revenue tax

Financing mechanism	External (%)	Everyone pays (%)	Pay or play (%)
Actual compensation[a]	1.4	1.4	1.4
Needed compensation[a]	1.4	2.2	−2.3
Funding factor[b]	100.0	63.5	−60.6
Contribution rate incumbent	0.0	1.2	0.0
Contribution rate entrant	0.0	1.2	9.4
Entrant market coverage	63.7	63.0	54.4

[a] Relative to USP-revenue in the non-USO case
[b] Actual compensation/needed compensation

Table 2 Model results with sequential simulation and a per-unit tax

Financing mechanism	External (%)	Everyone pays (%)	Pay or play (%)
Actual compensation[a]	1.4	1.4	1.4
Needed compensation[a]	1.4	1.9	−2.8
Funding factor[b]	100.0	76.4	−50.9
Per-unit tax incumbent[c]	0.0	1.0	0.0
Per-unit tax entrant[c]	0.0	1.8	9.6
Entrant market coverage	63.7	62.8	54.5

[a] Relative to USP-revenue in the non-USO case
[b] Actual compensation/needed compensation
[c] Expressed in % of the operator's gross revenue

to the fund raised from the market players equal the net costs previously computed (i.e. the black area in Fig. 2). The corresponding contribution rates are given in rows 2 and 3. In the "pay or play" scenario, the competitor's contribution rate (9.4%) is the highest by far as it is the sole contributor to the fund.

Row 3 shows the funds that would be needed to compensate the USP such that it is indifferent between the two scenarios with and without USO. Row 4 in Table 1 (revenue tax) and Table 2 (per-unit tax) reports for every funding mechanism the "funding factor", i.e. ratio of the actual compensation and that which would have been needed to leave the USP's profit after universal service provision and after compensation equal to its profit without universal service provision. Correct compensation occurs only if this funding factor is 100%. The results can be summarized as follows:

External Financing: The funding factor is equal to one in the case of government subsidies as the net costs are directly reimbursed and the market equilibrium is unaffected by the financing mechanisms.[13] There is no unfair compensation for the USP.
Everyone pays: With this sharing mechanism, the USP contributes the largest share to the compensation fund as it is the biggest operator in the market. Entrant cov-

[13] This assumes that the general tax needed to collect the funds needed is insignificant. Given that the postal sector is small compared to the economy overall, this is certainly the case.

erage remains about unchanged. However, only about two thirds of the actual net costs—i.e. the difference in profits in market equilibrium—are reimbursed and the remaining part is left to the incumbent. This results in an underfunding of the USP. *Pay or play*: The entrant revenue tax rate reaches 9.4% and results in a significant reduction in entrant market coverage (from 63.7% with external financing to about 54.4%). The reduced market coverage has a positive effect on the USP's profit and results in overfunding: With a revenue tax it receives compensation amounting to 60.6% of what it would have to pay in order to be indifferent between the two scenarios with and without USO.[14] Hence the negative sign on the funding factor in this case: The USP profit with USO and compensation is higher than without USO. Even without compensation (but with a taxation of the competitor), the USP is better off because of the USO as his monopolistic market segment is extended by the competitor's taxation which overcompensates the loss in the "unserved" market segment. With a per-unit tax, this effect is basically the same: The entrant now serves 54.5% of the market, while the funding factor is −50.9%. Hence, again, the USP is better off due to the USO and the competitor's contribution to the fund and hence would have to contribute, too. Instead, it receives compensation amounting to 50.9% of what it would have to contribute in order to be indifferent between the two scenarios.

We conclude that a two-step approach that first calculates net costs and later applies a sharing mechanism to collect the net costs results in an over- or underfunding of the USP depending on the sharing mechanism in place. This issue can be solved by determining the necessary compensation in market equilibrium, taking into account the output tax's impact on the operators ("integrated approach").

Note that the tax rates in Tables 1 and 2 are directly comparable: The contributions to the USO fund collected by a per-unit tax are expressed as a percentage of the operators' gross revenue. Taxation of the entrant in the "everyone pays a per-unit tax" scenario (1.8%) lies between the results in the "everyone pays a revenue tax" (1.2%) and a "pay or play" system with a revenue tax (9.4%).

The actual per-unit tax rates in Table 2 with an "everyone pays" mechanism are the same for both operators. As a fraction of gross revenue, the entrant's contribution is higher than the incumbent's due to his lower duopoly prices. Hence, in the "everyone pays" scenarios, with a per-unit tax, the entrant contributes relatively more to the compensation fund than with a tax on revenue. This results in a lower entrant's market coverage and a higher funding factor in the per-unit tax case.

A comparison of the "pay or play" scenarios in Tables 1 and 2 shows that collecting contributions to the fund by a revenue tax is more distorting than by a per-unit tax. In a more general setting, Anderson et al. (2001) show that per-unit taxation can be more efficient than a revenue tax under price competition with differentiated products when

[14] The funding factor reported in Tables 1–4 is defined as the ratio of the actual compensation it receives and compensation needed such that the USP's profit is unaffected by the USO. A funding factor of unity indicates that compensation is correct. If it is larger (smaller) than unity, the USP is overcompensated (undercompensated). A negative funding factor means that the USP is strongly overcompensated: Due to the entrant's reaction to taxation, the USP's profit actually increases due to the USO. Hence, needed compensation would be negative, while actual compensation is positive.

demand is sufficiently inelastic, which we assume in our simulations. The reason is that the two taxes differently affect the competitor's optimum pricing.[15]

4.2 Integrated approach

In the two-step approach discussed in the previous section, the output tax rates are determined to cover the calculated difference in *USP profits before compensation and taxation*. As shown above in Tables 1 and 2, this results in an imbalance if the compensation mechanism changes the market equilibrium. The main difference in the integrated approach is that the contribution rate is now determined such that the *USP profit after compensation and taxation* is unchanged compared to a scenario without universal service. Doing so, the net costs are computed in market equilibrium simultaneously with the necessary contributions.

When a tax is introduced, not only the black area in Fig. 2 grows or shrinks, but there are also variations in the other shaded areas which are taken into account in the integrated approach. Hence, a funding gap cannot occur by definition with any sharing mechanism.

Tables 3 and 4 provide the results. By definition, the funding factor is now 100% in all scenarios and hence there is no under- nor overfunding. It is straightforward that external compensation leads to the same figures as reported for the two-step approach (government subsidies do not further change the market equilibrium). Of highest interest are the results for the two sharing mechanisms.

Everyone pays: The compensation rate has two opposing effects. First, it compensates the USP for the net costs. Second, it raises the net cost as the output tax is levied on the USP as well which creates an additional need for compensation. This results in higher tax rates for full compensation in equilibrium compared to external funding.

Pay or play: The output tax is now substantially lower than in the sequential simulations (2.5% instead of nearly 9.4% with revenue tax or 2.3% instead of 9.6% with a per-unit tax) and it is also lower than in the case that everyone pays. The reason is the following: The asymmetric pay or play mechanism has stronger effects on the market equilibrium. As these effects work in favor of the incumbent, smaller compensation fund contributions are needed from the entrant. As tax rates are kept lower than in the two-step sequential approach (to avoid over-compensation), the entrant's pricing and coverage decisions are now much less distorted.

Note that the financing with a sharing mechanism affects not only unprofitable but also profitable products. Hence, these have to be considered as well in the calculation of the net cost of the USO; it does not suffice to just calculate the deficit of the unprofitable products.

Comparing the revenue tax and the per-unit tax as basis for contributions to the compensation fund, it is interesting to see that in our integrated approach the latter imposes a lighter burden on the entrant. The incumbent is affected relatively less by a

[15] This is obvious in the case of zero variable cost: The operator then maximizes revenue such that a revenue tax has no allocative effect while a per-unit tax affects the pricing decision. Hence, a revenue tax dominates over a per-unit tax. With positive variable cost and inelastic demand, the result may switch depending on revenue requirements.

Table 3 Model results with integrated simulation and a revenue tax

Financing mechanism	External (%)	Everyone pays (%)	Pay or play (%)
Actual compensation[a]	1.4	3.3	0.4
Needed compensation[a]	1.4	3.3	0.4
Funding factor[b]	100.0	100.0	100.0
Contribution rate incumbent	0.0	2.7	0.0
Contribution rate entrant	0.0	2.7	2.5
Entrant market coverage	63.7	61.9	61.3

[a] Relative to USP-revenue in the non-USO case
[b] Actual compensation/needed compensation

Table 4 Model results with integrated simulation and a per-unit tax

Financing mechanism	External (%)	Everyone pays (%)	Pay or play (%)
Actual compensation[a]	1.4	2.1	0.4
Needed compensation[a]	1.4	2.1	0.4
Funding factor[b]	100.0	100.0	100.0
Per-unit tax incumbent[c]	0.0	1.5	0.0
Per-unit tax entrant[c]	0.0	2.6	2.3
Entrant market coverage	63.7	62.4	61.6

[a] Relative to USP-revenue in the non-USO case
[b] Actual compensation/needed compensation
[c] Expressed in % of the operator's gross revenue

per-unit tax than by a tax on revenue as his price is higher than the entrant's. Hence, there is less need for compensation and lower tax rates for both operators. This allows for a higher entrant market penetration in the scenario with a per-unit tax than with a revenue tax.

5 Conclusions

In this paper we have shown that the net cost of USO—defined as the difference in the USP's profit with and without USO—very much depends on design of the compensation mechanism. If the USP is compensated from the general government budget, this does not (or only insignificantly) affect the market equilibrium. In this case, USO costing and financing are independent of each other. However, if there is a revenue or per-unit tax levied from the operators in the market in order to compensate the USP, this distorts the operators' decisions and has to be taken into account. If this is not done, in a sequential approach—as envisioned in the 3rd Postal Directive in the EU—the USP may be significantly over- or undercompensated. Our simulations show that a compensation fund to which all operators (including the USP) contribute according to their market shares may lead to an under-compensation of the USP. In

contrast, if the USP is excluded from contributions, this will unambiguously result in over-compensation.

We therefore propose an integrated approach to USO costing and financing in case national regulations implement a sharing mechanism. This implies that the regulatory authority sets the contribution rate in a way that the USP's profit remains unchanged comparing a situation without USO and one with USO *after compensation*. In particular, it turns out that it does not suffice to just calculate the deficit of the unprofitable products: As the financing affects also profitable products, these cannot be ignored in the costing of the USO.

We have only considered the private net costs of the USO. This is relevant when having to compensate the USP for its burden. However, there are also social costs (and social benefits) of the USO which include the difference of consumer welfare and the competitor's profit with and without USO. For a cost-benefit-analysis of the USO, these social effects would be the appropriate measures to consider. This is a possible extension of this paper. Further research is also necessary to assess not only the net cost of one single aspect of the USO but all dimensions usually in place, including pricing restrictions and the obligation to operate certain infrastructures.

Appendix: Model documentation

Our model approach is similar to the one in Valletti et al. (2002): There are two firms $i \in \{I, E\}$, each one offering postal services which are imperfect substitutes. There is a continuum $[0, 1] \subset \mathrm{R}_+$ of different markets, where the size of the total market is of unit size. We use a geographical interpretation of a market, such that market r stands for a local delivery route. Hence, the market can be divided into segments by region of delivery. If firm i decides to enter a certain market r it has to pay the incremental cost[16] associated with that market $f(r)$, where we assume that $f'(r) > 0$.

For the sake of simplicity, we make the following further assumptions:

Assumption 1 Markets are independent of each other. This implies that the competitive situation in one market does not affect the cost structure or demand in another market.

Assumption 2 The two operators I (incumbent) and E (entrant) possess the same technology (cost function) and compete in horizontally differentiated products.

Assumption 3 The sequence of decisions is as follows: First, a profit-maximizing incumbent chooses its optimum market coverage (geographical area coverage). Second, an entrant (competitor) sets its optimum coverage. Third, both operators set their price(s) for each of the delivery markets. If there is a universal service obligation, the incumbent's market coverage is exogenously set to 1 (full coverage).

Assumption 4 We focus on mail delivery and assume that the USO consists of a daily and nationwide mail delivery; there is neither a uniform pricing constraint nor

[16] We refer to the incremental cost associated with serving a market as "incremental coverage cost" in the sense that it is the cost incurred when an operator extends its regional presence incrementally.

restrictions on collection infrastructures etc. Hence, both operators can differentiate prices across regions.

Assumption 5 Marginal cost c_i is constant.

In every market r each operator makes a gross profit (or surplus) amounting to $s_i(r)$. Because all markets share the same demand characteristics and variable costs, the equilibrium prices in each market and therefore also s depend only on the number of competitors.[17] Typically, in the postal sector, $s_i(0) - f_i(0) > 0$, while $s_i(1) - f_i(1) < 0$. This implies that some regions are attractive to serve while others are not and market entry will generally occur, albeit not with full coverage.

From the perspective of operators, local delivery markets are ranked by increasing order of cost. Without USO, operators begin to cover the most densely populated areas and continue to cover less densely areas as long as it is profitable. Hence, each operator starts offering services from the market with the highest profit and leaves no gaps between served markets. If operator i serves all markets $[0, r_i]$, its total profit will be

$$\pi_i = \int_0^{r_i} s_i(r) - f_i(r) dr.$$

Solving the model backwards yields for the optimum market coverage of the entrant and the incumbent, respectively:

$$\tilde{r} = \underset{r_E}{\operatorname{argmax}} \int_0^{r_E} s_E(r) - f_E(r)\, dr,$$

$$\overline{r} = \underset{r_I}{\operatorname{argmax}} \int_0^{r_I} s_I(r) - f_I(r)\, dr.$$

Due to the assumptions made, total cost is convex. This implies that only one type of asymmetric equilibrium can arise in which one operator is bigger than the other. Here, due to sequence in Assumption 3, the entrant's coverage, $\tilde{r}$ is lower than the incumbent's, $\overline{r}$.[18] This is due to the incremental surplus in the monopolistic segment being larger than in the duopolistic segment: There is a mutual business stealing (quantity effect) and competitive pressure on prices in the duopoly region (price effect) such that

$$s_i^r \equiv s_i(r < \tilde{r}) < s_i^{r'} \equiv s_i(r \geq \tilde{r}).$$

[17] There is no reason for price differentiation within markets if the number of operators is the same because marginal costs do not vary across regions.

[18] In our model it is the sequence of decisions that results in the incumbent always serving at equilibrium a larger proportion of the market. This sequence reflects that the incumbent operator has traditionally been serving all markets due to the USO.

Hence, in the *absence of a universal service obligation*, the specific cost structure together with the market penetration decisions result in a natural segmentation of the entire market into three regions:

(1) In attractive market segments (e.g. densely populated delivery areas), it is feasible for both companies to operate in parallel ("competitive region", $r < \tilde{r}$).
(2) In less attractive local delivery markets (e.g. semi-rural areas), an operator can make a profit only if there is no competitor. Hence, there will be a monopolistic operator in equilibrium ("monopolistic region", $\tilde{r} < r < \overline{r}$).
(3) In the least attractive local delivery markets (e.g. rural areas), incremental coverage costs are higher than incremental surplus, such that no operator serves this segment voluntarily ("unserved region", $r > \overline{r}$). It is assumed that all regions $r > \overline{r}$ are served with P.O. box delivery by the incumbent.

The *introduction of a USO* forces the USP to upgrade to home delivery in areas $r > \overline{r}$ in which the incremental coverage cost exceeds the incremental surplus from extending market coverage. This replaces the operator's coverage decision in the sequence of decisions and potentially necessitates some kind of compensation.

The operators' surpluses result from price competition in the continuum of markets for mail. Price competition is driven by the users' demand for mail. We assume that there is one representative sender sending mail to destination region r having quasi-linear preferences with respect to money. All senders care about mail conveyed by the two I (incumbent) and E (entrant). We follow Dietl et al. (2005) and write total utility u of a customer for mail sent to region r as

$$u^r\left(q^r, m\right) = m + \alpha_I q_I^r - \frac{\beta}{2\gamma}\left(q_I^r\right)^2 + \alpha_E q_E^r - \frac{\beta}{2\gamma}\left(q_E^r\right)^2 - \varepsilon\frac{\beta}{\gamma}q_I^r q_E^r$$

where $\alpha, \beta, \varepsilon > 0$ and m is the amount of money spent on other goods. q_i^r is the quantity of mail sent to region r via operator i. A region in our model corresponds to a delivery route. The last term reflects the fact that the mail services offered by the two operators are not perfect substitutes but rather differentiated products. The higher the degree of differentiation, the closer parameter ε is to 0. Parameters α_i and β determine the market size and the slope of the demand curve. Note that utility as described above primarily represents the senders' preferences towards mail. However, demand for mail is also determined by the receivers' preferences. This is taken care of by parameter γ. A receiver's likeliness to cause mail depends on whether mail is delivered to the doorstep or needs to be picked up in a P.O. Box. Hence, the mode of delivery determines the value of γ

$$\gamma = \begin{cases} 1 & \text{with doorstep delivery,} \\ <1 & \text{without doorstep delivery.} \end{cases}$$

All households which are not served with doorstep delivery by the incumbent are assumed to still receive mail in a P.O. box.

By computing the first-order conditions of the Lagrange function associated with the utility maximization problem and solving the resulting equation system, we obtain the linear demand functions for the two operators' products

$$q_I^r\left(p_I^r, p_E^r\right) = \frac{\gamma}{\beta\left(1-\varepsilon^2\right)}\left(\alpha_I - \varepsilon\alpha_E - p_I^r + \varepsilon p_E^r\right)$$
$$q_E^r\left(p_E^r, p_I^r\right) = \frac{\gamma}{\beta\left(1-\varepsilon^2\right)}\left(\alpha_E - \varepsilon\alpha_I - p_E^r + \varepsilon p_I^r\right)$$

The two operators' gross profit (producer surplus) functions in region r write as

$$s_I^r = \left(\left(1-\mu_I\right)p_I^r - c_I\right)q_I^r\left(p_I^r, p_E^r\right),$$
$$s_E^r = \left(\left(1-\mu_E\right)p_E^r - c_E\right)q_E^r\left(p_I^r, p_E^r\right).$$

Parameters μ_I and μ_E are the output tax rates needed to finance the net cost of the universal service obligation in case there is a compensation fund and if taxes are raised on a revenue basis.[19] Maximizing producer surplus with respect to prices results in the two reaction functions:

$$p_I^r = \begin{cases} \frac{1}{2}\left(\alpha_I + \frac{c_I}{1-\mu_I}\right) & \text{if } r > r^* \\ \frac{1}{2}\left(\alpha_I - \varepsilon\alpha_E + \frac{c_I}{1-\mu_I} + \varepsilon p_E^r\right) & \text{if } r < r^* \end{cases}$$
$$p_E^r = \frac{1}{2}\left(\alpha_E - \varepsilon\alpha_I + \frac{c_E}{1-\mu_E} + \varepsilon p_I^r\right)$$

The case differentiation results from the market being divided into a monopolistic region and a duopolistic region according to the market coverage decisions.

Solving the reaction functions results in the following expressions for the incumbent's and the entrant's prices:

$$p_I^{r>\tilde{r}} = \frac{1}{2}\left(\alpha_I + \frac{c_I}{1-\mu_I}\right),$$
$$p_I^{r<\tilde{r}} = \frac{\alpha_I - \frac{\varepsilon\alpha_I}{2} - \varepsilon\alpha_E + \frac{\varepsilon\alpha_E}{2} + \frac{\varepsilon c_E}{1-\mu_E} + \frac{c_I}{1-\mu_I}}{2-\frac{\varepsilon^2}{2}},$$
$$p_E = \frac{1}{2}\left(\alpha_E - \varepsilon\alpha_I + \frac{c_E}{1-\mu_E} + \varepsilon\frac{\alpha_I - \frac{\varepsilon\alpha_I}{2} - \varepsilon\alpha_E + \frac{\varepsilon\alpha_E}{2} + \frac{\varepsilon c_E}{1-\mu_E} + \frac{c_I}{1-\mu_I}}{2-\frac{\varepsilon^2}{2}}\right).$$

These prices and the associated quantities determine the operator's surplus in each region r.

The incremental benefit of serving an additional market is given by the producer surplus as defined above. The operators' incremental coverage cost $f_i(r)$ is the first derivative of the total fixed cost $F_i(r)$ associated with serving all regions up to r:

$$F_i(r) = C + \delta_i r_i^{\theta}.$$

[19] In the case that taxes are raised on a unit basis, the surplus functions write as
$s_I^r = \left(p_I^r - c_I - \mu_I\right)q_I^r\left(p_I^r, p_E^r\right),$
$s_E^r = \left(p_E^r - c_E - \mu_E\right)q_E^r\left(p_I^r, p_E^r\right).$

The first part of total cost is fixed costs C which is independent of the area covered by the operators and their volumes. The second part reflects the time cost of delivery which increases convexly in the area covered according to the calibration of the parameters δ and θ.

Hence, both operators' profits are

$$\pi_I = \begin{cases} \pi_I(\overline{r}) = \tilde{r} s_I^r + (\overline{r} - \tilde{r}) s_I^{r'} - F_I(\overline{r}) & \text{if there is no USO,} \\ \pi_I(1) = \tilde{r} s_I^r + (1 - \tilde{r}) s_I^{r'} - F_I(1) + T & \text{if there is a USO,} \end{cases}$$
$$\pi_E = \tilde{r} s_E^r - F_E(\tilde{r}).$$

The last part of the incumbent's profit function with USO, T, reflects the transfer received as a compensation for providing universal services.

Given the incumbent's coverage, the optimum degree $\tilde{r}$ of the entrant's market penetration is

$$\tilde{r} = \begin{cases} 0 & \text{if } s_E(0) < 0, \\ 1 & \text{if } s_E(1) > \delta_E \theta, \\ \left[\frac{s_E^r}{\theta \delta_E}\right]^{\frac{1}{\theta - 1}} & \text{otherwise,} \end{cases}$$

where s_E^r is the entrant's surplus in the duopolistic market segments.

In analogy, without an USO, the incumbent penetrates the market to the degree

$$\overline{r} = \begin{cases} 0 & \text{if } s_I(0) < 0, \\ 1 & \text{if } s_I(1) > \delta_I \theta, \\ \left[\frac{s_I^{r'}}{\theta \delta_I}\right]^{\frac{1}{\theta - 1}} & \text{otherwise,} \end{cases}$$

where $s_I^{r'}$ is the incumbent's surplus in the monopolistic market segments.

Parameter μ (output tax / contribution rate) allows us to introduce various financing mechanisms. We consider three potential funding mechanisms to compensate the universal service provider:

(1) External financing:

$$\mu_I = \mu_E = 0$$
$$T \text{ such that } \pi_I(\overline{r}) = \pi_I(1)$$

where T is a direct subsidy from government funds. In this model, there is no (or zero) output tax and the net costs are reimbursed by the government directly.

(2) Everyone contributes:

$$\mu_I = \mu_E \text{ such that } \pi_I(\overline{r}) = \pi_I(1)$$

Consequently, there is no distinction between the universal service provider and the entrant who both pay output tax μ. In the sequential approach, π_i (1) is calculated with $\mu_I = 0$; $\mu_E = 0$.

(3) "Pay or play":

$$\mu_I = 0; \mu_E \text{ such that } \pi_I(\overline{r}) = I(1)$$

Again, in the sequential approach, π_I (1)is calculated with $\mu_I = 0$; $\mu_E = 0$.

In the third model, the USP is waived from the output tax. Note that this is a pay or play mechanism in the sense that either player either provides universal services or contributes to their financing. However, there is no choice for the operators whether the "pay or play". In our model specification and calibration it is optimal for the entrant not to offer universal services himself but rather to contribute to the fund.

The fund's budget restriction is satisfied if

$$T = \mu_I \left[p_I^{r>\tilde{r}} q_I^{r>\tilde{r}} (1 - \tilde{r}) + p_I^{r<\tilde{r}} q_I^{r<\tilde{r}} \tilde{r} \right] + \mu_E \left[p_E q_E \tilde{r} \right]$$

in the case that taxes are raised on a revenue basis and if

$$T = \mu_I \left[q_I^{r>\tilde{r}} (1 - \tilde{r}) + q_I^{r<\tilde{r}} \tilde{r} \right] + \mu_E \left[q_E \tilde{r} \right]$$

in the case that taxes are raised on a unit basis.

The model is solved numerically such that $\pi_I(\overline{r}) = \pi_E(1)$ holds for all three financing mechanisms, respectively.

The model is calibrated with data from Swiss Post in 2007. In Switzerland, there was a reserved area up to 100 g at that time. There were mainly competitors in the market for unaddressed mail and newspapers. Hence, the key parameters in Table 5 are calibrated for a partial monopoly version of the above model.

Volume, revenue and average price data stem from the annual report. In terms of price elasticity of overall demand Trinkner and Grossmann (2006) find in their empirical study for Switzerland a long-run price elasticity between −0.22 and −0.27. From his survey of studies, Robinson (2007) concludes that price elasticity measures for mail products typically range between −0.2 and −0.8 (see also Fève et al. 2006, for a recent study on mail price elasticities). In a similar exercise as ours, D'Alcantara (2006) choose a value of −0.3; Dietl et al. (2005) use values between −0.3 and −0.5 for different mail products. Since we expect price elasticity to further increase over time (see Trinkner and Grossmann 2006), we choose a value for price elasticity of demand in the high range of these estimates.

From these values, the model parameters are calibrated in Table 6.

We assume an entrant with a slightly different business model than the incumbent's. Based on evidence from Sweden and Denmark (Citymail), the Netherlands (Sandd, Selektmail) and other (partly) liberalized markets we assume that the entrant chooses to deliver less frequently than the incumbent does and is able to pay the employees lower wages than the incumbent. Hence, we assume lower fixed and marginal costs. On

Table 5 Empirical model calibration

Total volume	5′117m items
Total revenue	3′070m CHF
Average price	0.60 CHF
Total variable cost	45% of total cost
Time cost of delivery	30% of total fixed cost
Price elasticity of demand	−0.8

Table 6 Key model parameters

$\beta = -\frac{1}{\eta}\frac{p_I}{q_I}$	1.47×10^{-10}
$\alpha_I = \beta q_I + p_I$	1.35
α_E	1.05
δ_I	3.75×10^6
δ_E	2.00×10^6
c_I	0.3
c_E	0.25
γ (doorstep delivery)	1
γ (P.O. box delivery)	0.64
ε	0.70
Θ	2.70

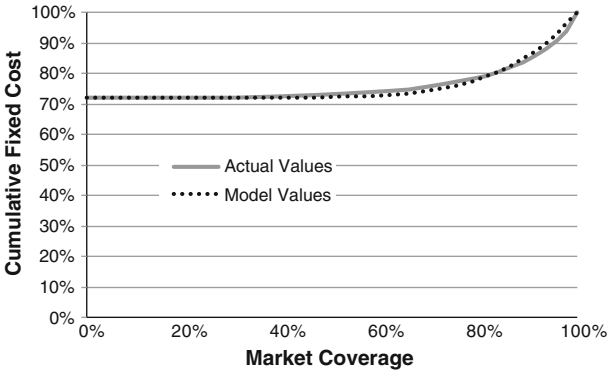

Fig. 5 Fitting of the incumbent's cumulative fixed cost function. *Source*: Swiss Post

the other hand, we calibrate demand such that more consumers chose the incumbent when both operators offer at the same price.

A critical part of the model calibration is the distribution of delivery time cost over households. The grey curve in Fig. 5 shows the actual values of delivery time in Switzerland with households being ordered by the time the postman takes to reach them. The values used in the model are represented by the black dotted line. We assume that the incremental coverage cost of covering an additional household is proportional to the time the postman needs to reach it. Then, the curves shown in Fig. 5 imply that

with full area coverage, the cost of delivery time accounts for about 30% of total fixed cost.

An analogous cost function is assumed for the entrant, taking into account the cost savings resulting from differences in the delivery strategy and wages.

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